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13. ABSTRACT *(Maximum 200 words)*

A theoretical study was made of the nonlinear dynamics of stratified flow past finite-amplitude topography, as a model for the generation of internal-wave disturbances by wind in the atmosphere. An approximate analytical theory was used to study the long-time development of finite-amplitude disturbances, in an effort to understand the conditions under which steady state is reached and whether transient wave breaking (flow inversions) is possible. A new kind of instability was discovered that sets in at topography amplitudes well below the critical amplitude required for breaking to occur; this instability grows at the expense of the mean flow. In the presence of instability, the flow is transient, fluctuating about the theoretically predicted steady state. There is no significant upstream influence, and no evidence of transient wave breaking was found. These results are consistent with laboratory experimental observations for moderate topography amplitudes.

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The overall objective of this project was to obtain a theoretical understanding of the nonlinear dynamics of stratified flow over topography, as a model for the generation of internal-wave phenomena by wind in the atmosphere. Specifically, the goal was to

(i) study the long-time behavior of transient disturbances in order to check whether finite-amplitude steady wave patterns form

(ii) understand the conditions under which 'wave breaking' (flow reversals and density inversions) may occur during the transient development of the disturbance.

To achieve these goals, we studied the flow of a Boussinesq density-stratified fluid of large depth past the algebraic mountain in the hydrostatic limit using the asymptotic theory of Kantzios & Akylas (*Proc. R. Soc. Lond.* A **440**, 639, 1993). This theory allows for slightly unsteady disturbances and can be used to examine the realizability of theoretically predicted steady states for subcritical topography amplitudes (below that required to cause overturning). Far upstream it was assumed that the velocity and Brunt–Väisälä frequency were constant. On the further assumptions that the flow is steady and there is no permanent alteration of the upstream flow conditions (no upstream influence), Long's model (Long, R.R., 1953, *Tellus* **5**, 42) predicts a critical amplitude of the mountain ($\epsilon = 0.85$) above which local density inversions occur, leading to convective overturning. On the basis of a linear stability analysis, we demonstrated that Long's steady flow is in fact unstable to infinitesimal modulations at topography amplitudes below this critical value, $0.65 \lesssim \epsilon < 0.85$. This instability grows at the expense of the main flow and may be attributed to a discrete spectrum of modes that become trapped over the mountain in the streamwise direction. The transient problem was also solved numerically, mimicking impulsive startup conditions. In the absence of instability, Long's steady flow is reached. For topography amplitudes in the unstable range $0.65 \lesssim \epsilon < 0.85$, however, the flow fluctuates about Long's steady state over a long timescale; there is no significant upstream influence and no evidence of transient wave breaking is found for $\epsilon \leq 0.75$. The theoretical predictions are consistent with the laboratory experimental observations of Baines & Hoinka (*J. Atmos. Sci.* **42**, 1614, 1985), which suggest that there is a range of moderately small topography amplitudes for which the flow does not reach steady state but develops slowly without breaking.

Detailed discussion of the techniques used and of the results can be found in the following publications:

Prasad, D., Ramirez, J. & Akylas, T.R. 1996 'Stability of stratified flow of large depth over finite-amplitude topography' *J. Fluid Mech.* **320**, 369–394.

Ramirez, J. 1993 Stability of nonlinear stratified flow over topography. SM thesis, Department of Mechanical Engineering, MIT.

Prasad, D. 1996 Dynamics of large-amplitude internal waves in stratified flows over topography. PhD thesis, Department of Mechanical Engineering, MIT.

Prasad, D. & Akylas, T.R. 1996 'Shelf generation by nonlinear waves in stratified flows', to be submitted for publication.

Prasad, D. & Akylas, T.R. 1996 'Dynamics of three-dimensional finite-amplitude internal waves', to be submitted for publication.